

Oxygen Containment System Options for Nuclear Thermal Propulsion Testing

Completed Technology Project (2014 - 2014)



Project Introduction

All nuclear thermal propulsion (NTP) ground testing conducted in the 1950s and 1960s during the ROVER/(Nuclear Engine Rocket Vehicle Application (NERVA) program discharged engine exhaust directly into the open air. However, due to current US Environmental Protection Agency (EPA) radiation protection guidelines and health regulations from the Nuclear Regulatory Commission (NRC), this practice is no longer acceptable. With NTP engine exhaust, hot gaseous hydrogen is nominally expected to be free of radioactive byproducts from the nuclear reactor; however, it does have the potential to be contaminated due to off-nominal engine reactor performance. One NTP ground testing option that has been documented by the ARES Corporation on Nuclear Thermal Propulsion Ground Test Facility (2006), which has been recommended as one of three acceptable ground test facility options, is to fully contain the engine exhaust. The concept in this particular ground test design is accomplished by injecting hydrogen exhaust with a high mixture ratio of oxygen that reacts with the hydrogen to produce steam. Oxygen and any trace amounts of radioactive noble gases released by off-nominal NTP engine reactor performance would then be captured, contained, and either held until the radiation has decayed to an environmentally safe/acceptable level (below background exposure) for release and/or treatment. The design concept goals in this project are to explore methods to minimize the overall volume of the containment system, more completely define the system requirements and designs, and then perform a systems trade study to validate feasibility, safety and cost.

The concept for this project is to take the hydrogen exhaust and inject it with a high mixture ratio of oxygen so the reaction produces steam. In theory, in a radioactive state, any trace amounts of radioactive noble gases released by off-nominal NTP engine reactor performance would be contained in the steam. Water is injected to condense the potentially contaminated steam into water. This water and the Gaseous Oxygen (GO₂) would then be captured in a containment area where the water and GO₂ would be divided into separate containment tanks.

Additionally, the project will also look at mechanisms that may minimize the storage requirements, thereby, reducing hazard risk of these respective systems by using two methods for GO₂ retention: (1) compressed gas storage system and (2) liquid storage. The compressed gas option would pump residual GO₂ from the containment area at near ambient pressure to a 1000 psi Maximum Allowable Working Pressure (MAWP) storage vessel. The liquid storage option flows GO₂ from the containment area through a liquid nitrogen (LN₂) heat exchanger to liquefy the GO₂ and store the liquefied oxygen (LO₂) in a vacuum/LN₂ jacketed tank for storage, decay, and subsequent disposal.



Logo for the Office of Chief Technologist

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Anticipated Benefits

The oxygen containment system that is being developed to fully contained NTP ground testing exhaust will directly benefit NASA funded missions to Mars by enabling safe ground testing of nuclear rocket engines that align with currently acceptable health and environmental regulations. The large thrust for long duration and high specific impulse provided by nuclear rocket engines greatly reduce the propellant mass, therefore a smaller vehicle can be designed for cargo missions. Enabling this capability will ultimately provide safer more affordable travel to Mars and beyond.

The oxygen containment system that is being developed to fully contained NTP ground testing system benefits NASA unfunded missions and planned missions by enabling safe and affordable ground testing of a NTP rocket engine. If NASA does plan to meet it's long term vision of having manned missions to Mars by 2033, and be technologically prepared to accomplish this goal, capabilities that enable this mission to occur safely and affordable, need to be developed now.

Benefits to the commercial space industry would be similar to those provided to NASA; a method to safely and affordably ground test a NTP rocket engine would be enabled.

Benefits to other government agencies would be similar to those provided to NASA. A novel approach to treating nuclear exhaust from a NTP engine that utilizes an oxygen containment system, will allow other governmental agencies to test and use nuclear powered devices (i.e. Army, Navy). Additionally, regulatory agencies could potentially be provided with alternate options, that don't currently exist, to address issues related to capturing any nuclear exhaust.

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Stennis Space Center (SSC)

Responsible Program:

Center Innovation Fund: SSC CIF

Project Management

Program Director:

Michael R Lapointe

Program Manager:

Ramona E Travis

Project Manager:

Ke Nguyen

Principal Investigator:

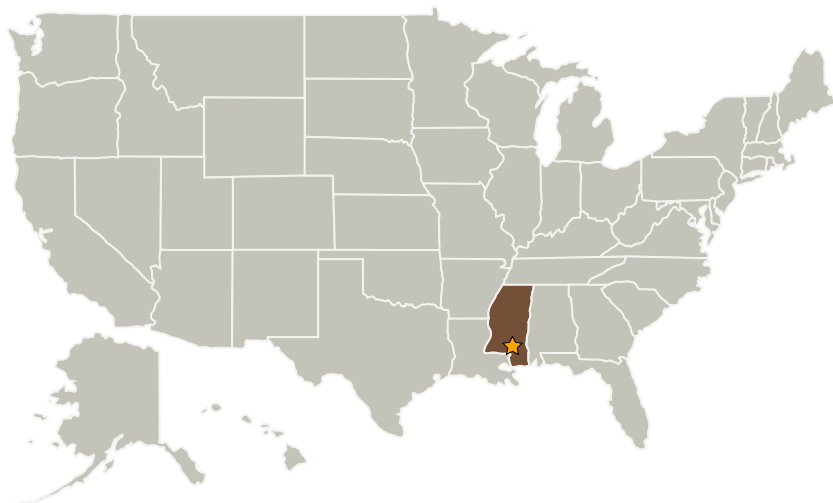
Ke Nguyen

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Primary U.S. Work Locations and Key Partners



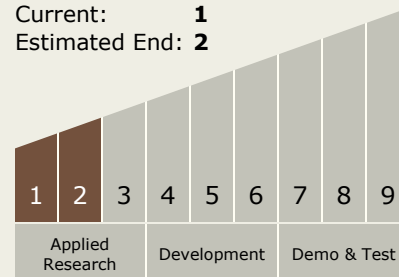
Organizations Performing Work	Role	Type	Location
★ Stennis Space Center(SSC)	Lead Organization	NASA Center	Stennis Space Center, Mississippi

Primary U.S. Work Locations

Mississippi

Technology Maturity (TRL)

Start: **1**
 Current: **1**
 Estimated End: **2**



Technology Areas

Primary:

- TX01 Propulsion Systems
 - TX01.4 Advanced Propulsion
 - TX01.4.3 Nuclear Thermal Propulsion

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Images



Office of Chief Technologist

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(<https://techport.nasa.gov/image/4039>)

Stories

REVIEW OF NUCLEAR THERMAL PROPULSION GROUND TEST OPTIONS

(<https://techport.nasa.gov/file/21937>)

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(<https://techport.nasa.gov/file/21936>)